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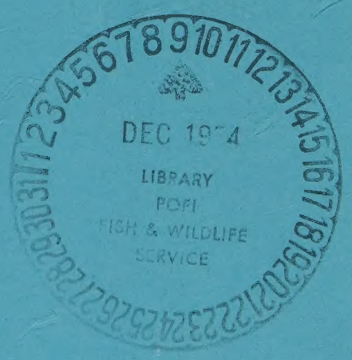
The Food of the Whiting, and a Comparison with that of the Haddock

By R. JONES, B.Sc.



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By R. JONES, B.Sc.

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The Food of the Whiting, and a Comparison with that of the Haddock

INTRODUCTION

ırly references to the food of whiting, *Gadus merlangus* L., are found in the works of Yarrel and Day, :scribed it as a "voracious creature feeding indiscriminately on small animals". Matthews (1887) ıed the stomachs of some 400 large whiting from the east coast of Scotland and found that the h contents were principally made up of fish and Crustacea, only 5% of the stomachs containing :esentatives of either group. Young sprats were the chief item in his collections from the Moray nd off Stonehaven.

:rdman, Corbin and Scott (1893) examined the stomachs of 223 O-group whiting taken during ı from the Cheshire Dee, the River Mersey and off Morecambe. Six species were given, sug- that the principal food was small Crustacea, including Crangon, Mysis, Eurydice, Corophium, poda and Copepoda. Lists of food species given by Scott (1902) for whiting from the east coast of d showed that they also were principally feeding on small Crustacea. Few fish were recorded, kopleura was not uncommon and a large number of copepods are listed.

more detailed report on the food of the 'Scottish' whiting was made by Smith (1889-92) who d the number of stomachs showing each food species. He examined more than 1,000 stomachs, ally from the Firth of Forth, and found that the most commonly occurring species were Crangon, us, herring, whiting, Eupagurus, Portunus and Ammodytes, in that order. Todd (1907), ; on whiting from the southern North Sea, expressed his results in a similar manner besides ıg the number of organisms per stomach. The principal food species found were *Crangon allmanni, us bernhardus, Gastrosaccus spinifer, Ammodytes tobianus* and herring. Blegvad (1916), working on from the Kattegat, attempted a more exact quantitative estimation of the food by estimating ghts of the food organisms and expressing these as proportions of the body weight. He stated ıiting from the South East Kattegat were feeding almost exclusively on *Haploops tubicola,* while ll fish in the fjords were feeding on gammarids, *Crangon vulgaris,* mysids, *Gobius ruthensparri* and *elagica.*

rtling (1938), writing on southern North Sea whiting, gave the numbers, weights and calorific of different food organisms, among which young herring, Ammodytes, whiting, Branchiostoma, n, Portunus, Corystes, Amphipoda, Copepoda, Alloteuthis, *Limacina retroversa,* Nephthys, Lanice hiurus are worthy of note. He concluded by stating that the whiting is an active predator, on small swimming creatures besides biting off the feet of molluscs such as *Arctica islandica* and ɔecies, and it is this conception of a fish feeding on active rather than sedentary organisms that ɔmmon conclusion to be drawn from all these works, although, of course, the actual species eaten t always have been the same.

rning now to the food of haddock, *Gadus aeglefinus* L., a considerable amount of work has been out, of which the principal was that undertaken by Ritchie (1937). Other workers of note were 1886), Todd (1907), Poulsen (1928), Ogilvie (1938), Homans and Needler (1944) and Brown and 1946). Ritchie's work covered the food and feeding habits of haddock in Scottish waters, and anised on a regional basis, each area corresponding to an area of specific haddock growth rate as by Thomson (1927). In contrast to the whiting, the haddock was shown feeding primarily on y animals, echinoderms, annelids, molluscs and Crustacea. Fish remains were generally cant apart from the consumption of Ammodytes in certain areas from August to December.

all food determinations it is necessary to distinguish between (*a*) the food eaten (ingested), (*b*) found in the stomach at any time, and (*c*) the food assimilated in the growth and health of the r, i.e. food value of the organisms consumed. The first is primarily a measure of the toll exerted ɔredator upon the food species and is difficult to assess directly except in a controlled laboratory ent. The second is the most easily ascertainable, and in the usual direct investigations of a natural ıity is the only immediate measure of either the first or the third. It is, however, only the residual

component at any time of a more or less continuous process of ingestion, digestion and assimil In this, to some extent, it is comparable with the "standing" crop of plankton in relation to that *p* and that *consumed*. The third is of most direct significance in studying the predator but is very di to assess in any direct manner. Only in so far as the stomach contents are a first measure of it data reviewed above and those examined here contribute to that assessment, and only in so far processes of digestion can be allowed for are they a satisfactory measure of the first.

Because of the increasing importance of whiting in Scottish landings, it was decided to m more detailed examination of its food, both for its own sake and with a view to comparing it wit of the haddock. This work was carried out from the Marine Laboratory, Aberdeen, when the a was in receipt of a grant from the Development Commission.

MATERIAL AND METHODS OF ANALYSIS

Whiting stomachs were collected by the research vessels of the Scottish Home Department period extending from November 1948 to December 1949. The positions of samples taken each from the North Sea are recorded on Fig. 1, where it is seen that sampling was principally carried ou the north-west and central North Sea, corresponding with the greatest centres of density of w distribution at the time (Ellis, 1950). Before removing the stomachs for preservation, the whiting first separated into length groups as follows:—<21, 21-25, 26-30, 31-35, 36-40 and>40 cm. Fi less than 21 cm. in length were preserved entire in 5-10% formalin. For the larger fish the gu removed at sea.

The relative quantities of different organisms found in the stomach provide a first estimate food consumed. They may be assessed by (1) measuring their respective weights (or volumes estimating the proportion of stomachs containing each food species, and (3) estimating the actual nu of organisms per stomach.

Each of these estimates of the food eaten, however, may be subject to bias due to the differen of the various food species and their rates of digestion by the whiting. If, for example, fish were fe on annelids and echinoderms and equal weights of each were eaten per unit time, then the proba of finding an annelid in the stomach may well be less than that of finding an echinoderm, since the may be expected to be digested at a slower rate. Consequently, the proportion of stomachs conta echinoderms would tend to be greater than those containing annelids, despite the fact that equal quan of each were being eaten. Similarly the percentage weight of echinoderms in the stomachs would to be greater than that of annelids.

Because of this bias, an absolute estimate of the true quantity and proportions of food species eaten in a given time cannot be made without a knowledge of the rates of digestion of different organisms. This, however, need not prevent comparisons being made between different sam Accordingly, the results in the following pages have been presented so as to demonstrate the ge nature of the food and such variations in the relative proportions of the food organisms as may be app from sample to sample.

Quantitative estimates of stomach contents may be made by either weight or volume and the of either depends largely on the nature of the stomach contents. In order to measure the variati the quantity of food from stomach to stomach, weighing is preferable, since the amount of food stomach which is almost empty may be too small for accurate volumetric measurement. Pro there are only one or two food species per stomach these may also be weighed separately, but if are a great many species it may be more practical to estimate their proportions in the sample as a wh volumetric displacement, rather than make a large number of weighings for each stomach individ

The proportion of stomachs in which recognisable remains of each species are found should be recorded. Since this is a measure, even though a biased one, of the relative (not absolute) freq with which different food species are ingested, there is nothing to be gained by including the

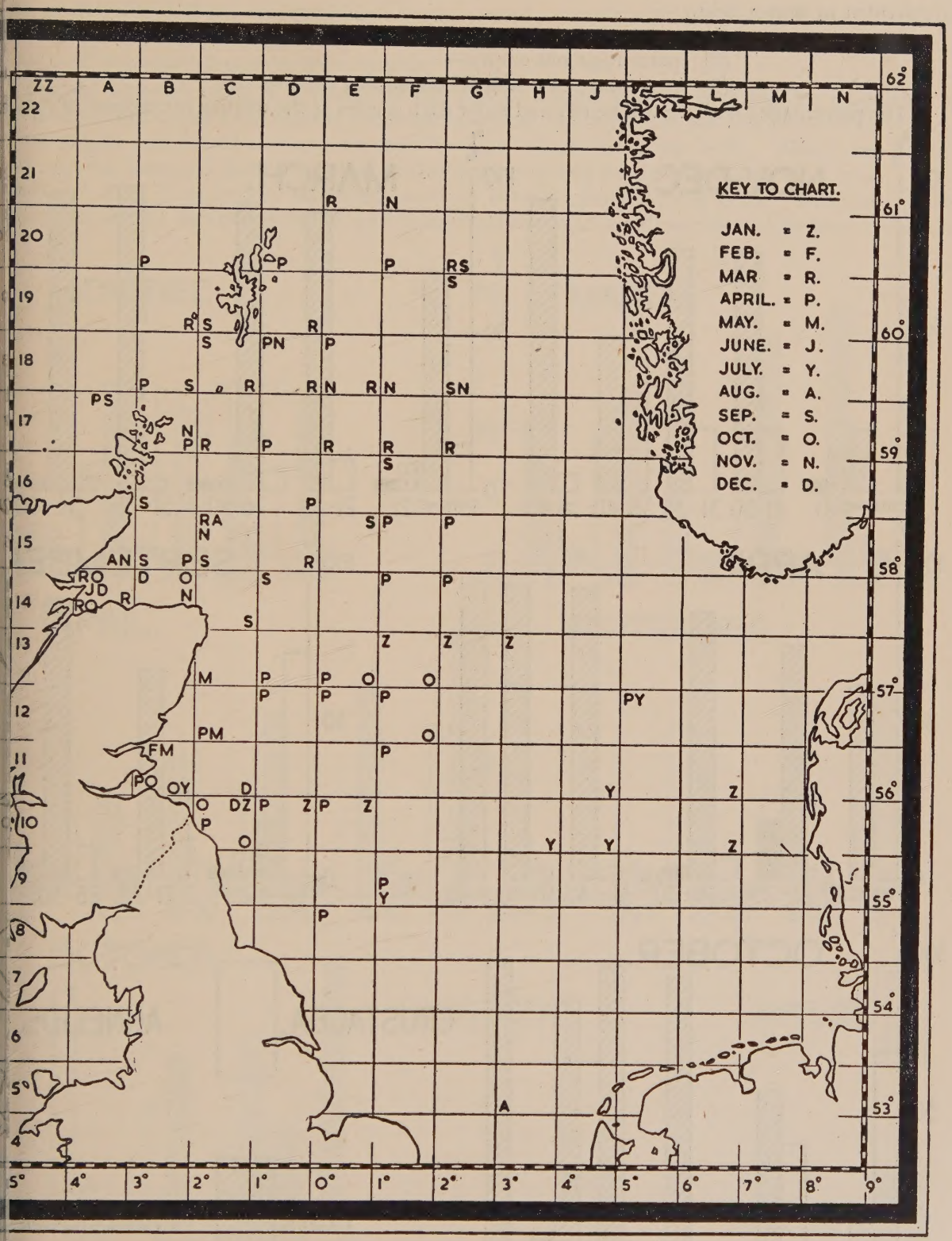


Chart showing positions and months in which whiting samples for stomach analysis were taken over the period November 1948-December 1949.

stomachs in the total. For the purpose of this report, therefore, the stomachs in each sample have sub-divided as shown below:—

(1) percentage empty
(2) percentage not empty—
(3) percentage of group (2) containing each species.

The percentage (3) above will be referred to for each species as the relative occurrence of that s

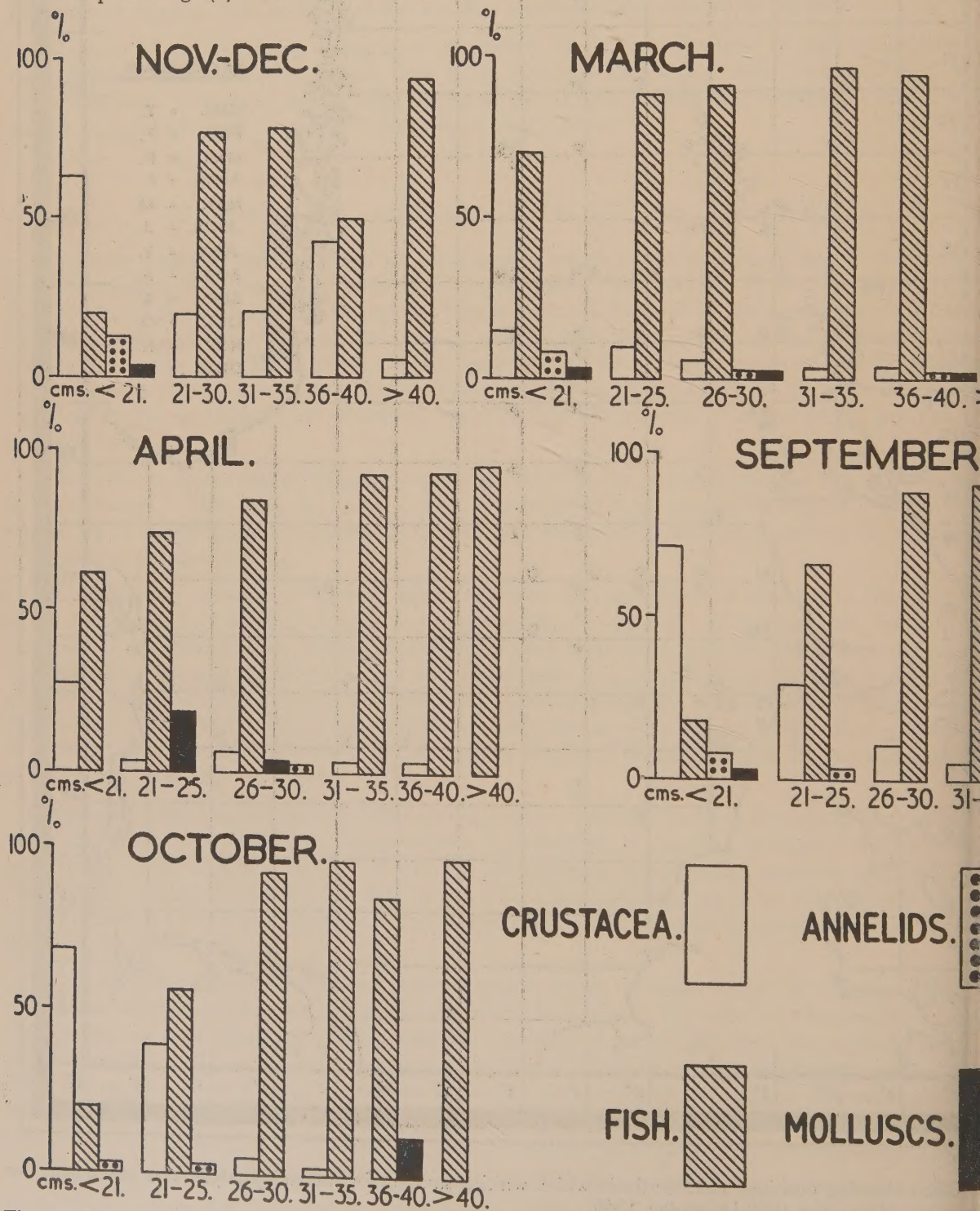
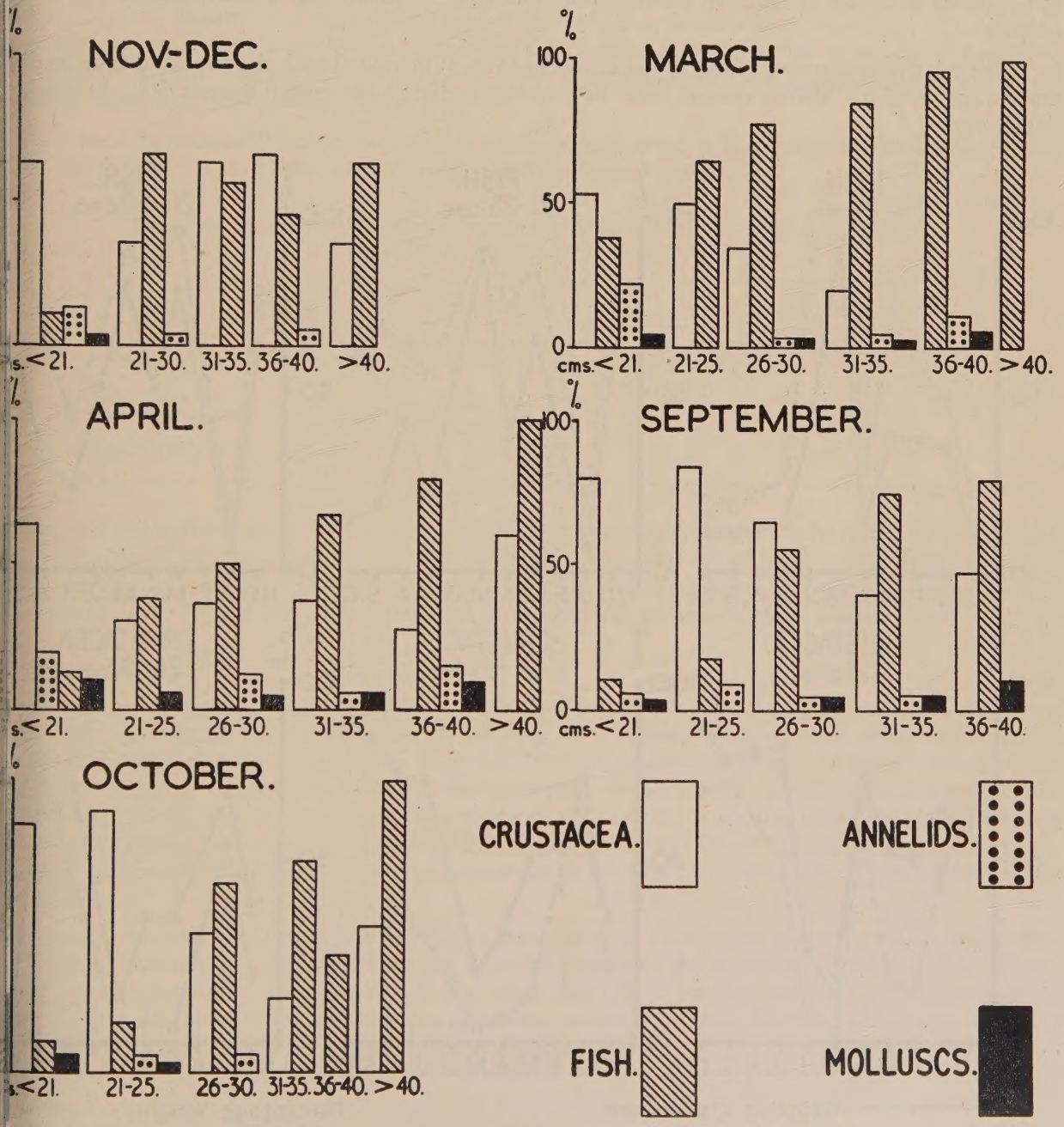


Fig. 2 Histograms showing the percentage weights of different animal groups found in the stomachs of w of various sizes.

FOOD OF THE WHITING: GENERAL

The chart in Fig. 1 shows that sampling was not carried out sufficiently intensively to enable regional aparisons to be made month by month. Instead the results have been classified according to the dif- nt types of organisms found in the stomachs.

In general, stomach contents consisted of fish and Crustacea, with a much smaller proportion of ielids and molluscs, and only isolated occurrences of echinoderms. The relative proportions of these ups by weight and occurrence are recorded for each month in Tables I–VI. Within the limited a and material surveyed there was, generally for any size group in any month, about as great a simi- ty between data from widely separated areas as between neighbouring ones. There are a few eptions that will be mentioned below, and more detailed work would doubtless show some consistent



3 Histograms showing the relative occurrence of different animal groups found in the stomachs of whiting of various sizes.

regional differences. It is considered, however, that the results from various regions are suffi consistent to enable certain generalisations to be made here concerning the area as a whole. detailed data are filed in the laboratory for consultation if required.

Fig. 2 shows the percentage weights of different animal groups in the stomachs of whiting of v sizes for those months when whiting of all sizes were obtained. The principal groups were fish, crusta annelids and molluscs, of which the first two were the dominant.

Fish

The percentage weight of fish in the stomachs increased with the size of whiting, with a corresp decrease in the proportions of Crustacea. During the spring the percentage weight of fish exceede of Crustacea in all size groups. In autumn, fish predominated in whiting of more than 25 cm. in only.

The relative occurrence of fish in the stomachs (Fig. 3) increased with the size of whiting as c percentage weights. Values ranged from 10% in the under 21 cm. group to over 90% in the size-groups.

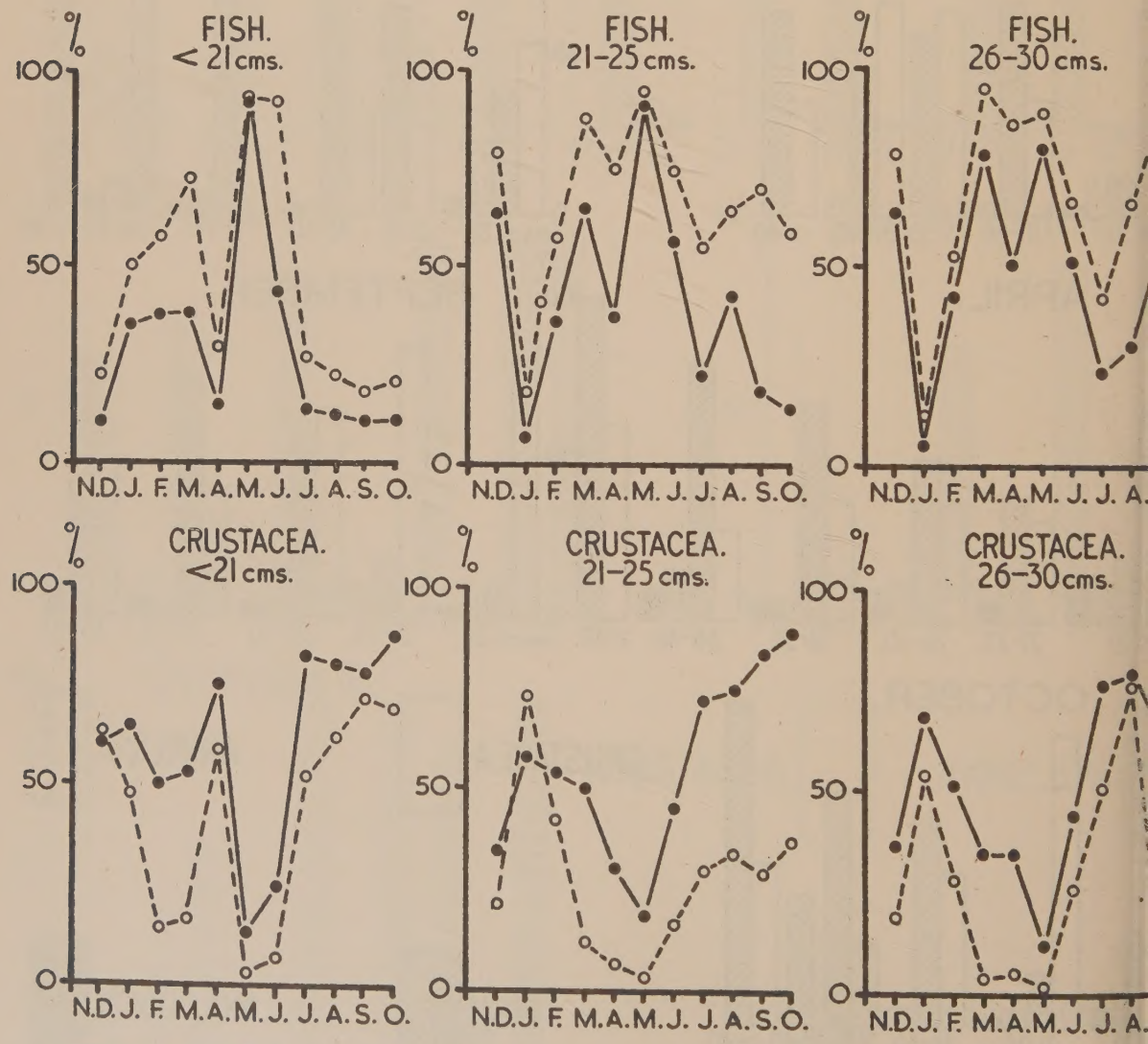


Fig. 4 Showing the relative occurrence and percentage weights of fish and crustaceans found in the sto of whiting of various sizes during the year.

The importance of an organism in the food depends not only on the quantity digested per unit time, also on its food value, of which calorific value is one expression. It was shown by Hertling (1938), king on whiting from the southern North Sea, that weight for weight the calorific value of fish was ut twice that of crustaceans and was almost twice that of other animals. If, then, calorific values e to be taken into account when assessing the relative importance of the different organisms in the , it may safely be concluded that, in all but the whiting of less than 21 cm., during the latter half of year, fish were most important in the diet. This should be true even if the bias mentioned on page 6 e operating so as to over-emphasize somewhat the true proportions of fish in the food.

Any attempt to establish significant monthly fluctuations (Fig. 4) in the proportions of fish eaten is ıpered by the fact that monthly comparisons are not always distinguishable from regional comparisons. ıs, for instance, although the peak month for fish (by weight and occurrence) was May, when propor- s of 90% or more were recorded, sampling was then confined to the statistical square C13c and so e cannot be directly compared with the much lower proportions observed in January, April and July amples taken from the Central North Sea.

That some regional differences in stomach contents may occur is illustrated by the comparison of and other forms in stomachs taken during July from several areas:—

Percentage Weights and Relative Occurrence of Different Organisms in Whiting Stomachs of 21-25 cm. Taken from Two Areas Sampled in July

Area \ Food	Relative Occurrence				Percentage Weights			
	Fish	Crustacea	Annelids	Molluscs	Fish	Crustacea	Annelids	Molluscs
Moray Firth and St. Andrews Bay ..	40	65	5	2	88	11	1	+
Central North Sea ..	15	77	2	3	32	43	16	8

Moray Firth and St. Andrews Bay fish were feeding principally on Ammodytes and *Gadus esmarkii*, eas the central North Sea samples contained a greater proportion of Crustacea, annelids and molluscs. The percentage weights of fish in the larger whiting (over 30 cm. in length) were very high, rising to or more in the largest fish (over 40 cm.) so that there was no well-marked seasonal trend.

STACEANS

The relative proportions of Crustacea (by weight and occurrence) in the whiting stomachs are shown igs. 2-4. Owing to the insignificant proportions of annelids, molluscs and echinoderms in the achs, the remaining percentage after allowance for the percentage weight of fish in the stomachs principally due to crustaceans. Consequently, whereas the percentage weight of fish increased with of whiting, so the percentage weight of crustaceans decreased. A similar trend, however, was also n by the relative occurrence of crustaceans, which is not dependent on the percentage due to fish, it may be concluded that there was a real decrease in the rate of consumption of crustaceans in the r whiting.

Although the percentage weight and relative occurrence of crustaceans generally follow each other closely, the latter is considerably greater than the former in the stomachs of whiting of 21-35 cm. ngth during autumn. This was due in the small fish (21-25 cm.) to the presence of a negligible ht of copepods, amphipods and larval crustaceans recorded in some 30-40% of the stomachs, and e larger fish (26-35 cm.) to an abundance of *Hyperia galba*.

ELIDS

The proportion of annelids in the stomachs was very low in most samples, with an overall average rrence of only 9%. Comparisons of stomachs taken from the central and northern North Sea at

similar times of the year show that the proportion of annelids in the stomachs was greater in fish from the former area, as is shown below:—

21-25 cm. Whiting

Area \ Month	November and December		July		October	
	% Occurrence	% Wt.	% Occurrence	% Wt.	% Occurrence	% Wt.
Central North Sea	5	3	19	14	12	2
Northern North Sea	—	—	3	2	5	10

26-30 cm. Whiting

Area \ Month	April		July		October	
	% Occurrence	% Wt.	% Occurrence	% Wt.	% Occurrence	% Wt.
Central North Sea	40	13	14	4	20	1
Northern North Sea	19	10	20	13	—	—

No records of annelids were obtained from the stomachs of fish of more than 40 cm. in length.

Molluscs

Molluscs were very poorly represented and were recorded from an average of only 3% of the sto None were found in stomachs of whiting of more than 40 cm. in length. The relative occurre annelids and molluscs was much the same in all other size groups, whereas their percentage weight greatest in the smaller whiting. It would appear then that their insignificance in the larger w was chiefly due to the great increase in the weight of fish eaten rather than to the decrease in the qu of these animals consumed (see Figs. 2 and 3).

Echinoderms

Echinoderm remains were very scarce and were recorded from only 9 out of some 3,000 stom fish less than 25 cm. in length. No traces were found in the stomachs of whiting larger than th

FOOD OF THE WHITING: SPECIFIC

The relative occurrence and weights of the actual species eaten are shown in Tables VII-X percentage weight of each species being calculated as a percentage of the weight of all member own phylum and not of the total mass of food. In addition a complete list of the species f appended in Table XVII.

Fish

Young Ammodytes constituted more than 60% of the fish eaten by small whiting (less than in length) and were recorded in each month except January. Small whiting and *Gadus esmarkii* oc from time to time in a few stomachs from July onwards, but no young haddock were found.

In all the larger whiting (>20 cm.), gadoids were the principal food species, although ag haddock were taken. The most prominent food species was *Gadus esmarkii*, with the addition of C

iting from July onwards. *Ammodytes spp.* only formed an appreciable proportion of the food in the machs of 21-30 cm. fish taken from the Firth of Forth and off the Aberdeenshire coast in May, when ey were present in 90% and 75% of the stomachs respectively. They were also prominent in the diet 21-25 cm. whiting taken from the Moray Firth in March, whereas *Gadus esmarkii* was the principal n in all the northern North Sea samples.

In contrast no gadoids were recorded from the stomachs of the six samples of whiting taken m the southern North Sea (square H5c) in August, in which herring, Solea and *Ammodytes spp.* re the principal forms.

Other species recorded were long rough dabs, *Gobius minutus, Callionymus lyra* and Argentina. Herring wn and Branchiostoma were recorded in several stomachs of the 26-30 cm. whiting.

USTACEANS

The principal crustacean species both by weight and frequency of occurrence was *Crangon allmanni,* ich was present in most samples throughout the year. Other Decapoda, particularly Pandalus, ca, Portunus and Eupagurus, were prominent in the stomachs of all size groups, with the exception fish over 30 cm. in length in which the two latter species were rarely recorded. Mysids were present most samples of under 21 cm. whiting, although they only attained prominence by weight in January July when they formed 16% of the Crustacea found. In the larger whiting, mysids and euphausids re prominent only among the fish taken from the central North Sea in January and July. Amphipods, efly lysianassids and ampeliscids, were present in nearly all samples, often occurring in twos and ees in stomachs otherwise full of fish. On the other hand, Hyperia and Themisto were present during otember in the stomachs of small whiting (under 21 cm. in length) in quantities sufficient to distend ne 10% of the stomachs and were probably being specifically selected by these fish. This too was the e among the 26-35 cm. whiting taken from the Montrose Bank in August, when more than 70% of stomachs were distended with these species. Copepods and larval decapods were present in the machs of whiting of less than 26 cm. in length during autumn. Other species of Crustacea were orded from time to time, of which the principal were *Hippolyte securifrons, Galathea spp., Munida ffica, Calocaris macandreæ, Cirolana borealis,* with several Amphipoda (including *Proto pedata*) and Cumacea. ist of all crustacean food forms is appended in Table XVII.

NELIDS

The annelids present in the stomachs were restricted to 17 recognisable forms, all but five of which e errant polychætes. The principal representatives were *Goniada maculata, Phyllodoce spp., Nephthys* , polynoids, *Pectinaria auricoma, Hyalinœcia tubicola* and *Amphytrite spp.*

LLUSCS

The molluscs were chiefly represented by small cephalopods, of which *Loligo forbesii* was the principal cies. In addition, a few stomachs were found to contain *Sepiola atlantica* and portions of the feet of elks. One specimen of *Loligo media* was recorded from a whiting captured in April from area F9c. all gastropods and bivalves were only recorded on isolated occasions from the stomachs of the smaller (less than 26 cm. in length).

HINODERMS

Echinoderms remains were very rarely recorded from the stomachs, portions of *Amphiura filiformis, iura affinis* and a small holothurian being all that were found.

FOOD OF THE HADDOCK

Ritchie (1937) has provided a detailed survey of the stomach contents of haddock in Scottish catches, this provides a reliable basis for a comparison with the stomach contents of the whiting. There is, vever, considerable variation in food found (and its availability) from time to time and place to

place, and it was considered desirable to obtain supplementary evidence of the stomach contents of had taken at the same time and place as the whiting already considered. Only a limited number of had stomachs (about 900) have been examined in this work, but the information derived from these is so sir to that provided by Ritchie (1937) that they seem adequate for the purpose.

Unlike whiting stomachs, those of haddock were all found to contain a large number of food spe For this reason it was found more practical to estimate their proportions in the sample as a whol volumetric displacement than to make a considerable number of weighings for each stomach individu Before proceeding with this technique, however, a number of stomachs were analysed, using both we and volumes. These results are summarised in the table below and it is evident that the percen weights and volumes of the different food groups in each size category of haddock were almost ident

Estimates of the Proportion of Different Animals in a Sample of Haddock Stomachs by Volume and Weight

Size of haddock \ Food animal	Fish		Crustacea		Annelids		Molluscs		Echinoderms	
	% Vol.	% Wt.	% Vol.	% Wt.	% Vol.	% Wt.	% Vol.	% Wt.	% Vol.	% Wt.
26-30 cm.	—	—	59	56	7	10	17	16	18	20
31-35 „	10	12	41	42	13	12	10	12	24	28
36-40 „	36	32	34	34	10	10	9	10	9	9
Mean difference:	1		1		1		1		2	

Accordingly the remaining analyses were carried out by volumetric displacement only. relative occurrence of each food species was also estimated and the results of these analyses are sho Tables XVIII-XIX.

In accordance with the results obtained by Ritchie (1937), the food was found to be princi echinoderms, annelids, molluscs and crustaceans. As Ritchie found, fish were also intermitt important in the diet, and samples taken in May and September from the Firth of Forth and M Firth respectively are worthy of mention in this respect. During these two months the relative occur of fish ranged from 20% to 44%, with a corresponding range of percentage volumes of 25% to The principal fish consumed in May by haddock of less than 26 cm. in length was Ammodytes, which present in some 33% of the stomachs.

In the larger haddock, Ammodytes and also *Gadus esmarkii* were present only in some 4-8% o stomachs and the remaining percentages (in September) were due to the presence of herring and he spawn. The proportions of fish consumed during other months were quite insignificant, recorded being *Gadus esmarkii*, Sebastes, Trigla, Gobius and long rough dab. No haddock were f either by Ritchie or in this work.

Crustacea were present in an average of 50% of the stomachs collected but comprised only 7 the total volume of food present. The principal forms consumed were *Crangon allmanni* and amphi with the addition of Nika, Pandalus, Galathea, Portunus, Eupagurus, mysids and euphausids.

Annelids and molluscs were each present in 51% of the stomachs and together formed 25% o food material present. Of the annelids consumed both errant and sedentary polychætes were eq represented, polynoids, Goniada, Nephthys, Hyalinœcia and Pectinaria being the principal t Molluscs were principally represented by small bivalves, including *Abra spp., Cultellus pellucidus, Sp sp., Cardium spp., Pecten similis* and *Tellina spp.* Small gastropods, of which *Cylichna cylindracea* wa principal, were also recorded, but cephalopods and Buccinum feet were found in only 3 or 4 stomac haddock 31-35 cm. in length.

Echinoderms occurred in 75% of the stomachs and formed 31% of the volume of food material. ly six genera were recorded and of these Ophiura, Amphiura and Echinocyamus were the principal. hiopholis and Strongylocentrotus were present in the stomachs of fish exceeding 26 cm. in length l there were a few isolated records of holothurians.

A complete list of the species found in the stomachs of haddock of various sizes during this survey is ended in Table XVII. For more complete reference the work of Ritchie (1937) should be consulted.

FEEDING OF WHITING AND HADDOCK COMPARED

From the foregoing description of the food of whiting and haddock taken together in the North , it is clear that fish played the most important part in the food of whiting, whereas annelids, molluscs l echinoderms featured much more prominently in the diet of the haddock. The magnitude of this erence is shown quite clearly in Table XIX, where the ratios for each phylum of percentage weight in ting to percentage volume in haddock are given. Whilst unusual, such a comparison may be justified the evidence presented in the Table on p. 14. These ratios (which are based exclusively on com- isons of fish taken in the same hauls) show that, with the exception of the May and September ples, the proportion of fish in the whiting stomachs was considerably greater than in those of haddock, that in many cases no fish at all were present in the haddock at times when the whiting contained a proportion.

Although in September the ratios of the proportion of fish in whiting stomachs to those in haddock ged from 20.0 to as low as 1.1, the difference between the two species was really more marked, since ting at this time were feeding on Ammodytes and gadoids, while the haddock stomachs chiefly tained young herring and herring spawn. In May, however, both whiting and haddock were eating modytes to some extent although the proportion in the whiting was at least twice that in the haddock, for size.

Echinoderms, on the other hand, were practically absent from the whiting stomachs but present in e 75% of the haddock stomachs. In no case did the whiting/haddock ratios for annelids and molluscs ed unity and the ratio was generally very low owing to the much greater consumption of these nals by haddock than by whiting.

The ratios for Crustacea fluctuated above and below unity, showing a tendency for the proportion rustacea eaten to be somewhat similar in these two fish, as was also true of the actual species of stacea consumed.

Observations on the anatomy of whiting and haddock make it clear that these two fish may be cted to have different feeding habits. The small crushing teeth, ventrally placed mouth and barbel ie haddock are all suggestive of an omnivorous bottom feeder, in contrast to the sharp teeth, more inal mouth and absence of barbel in the whiting which are characteristic of an active predatory This is further borne out by Muir Evans' comparison (1940) of the comparative anatomy of the ns of fish, in which it is shown how different modes of feeding are associated with different brain tures. He describes the small somatic-sensory lobes and large facial lobes of the haddock, which are iated with balance and the taste buds on its barbel respectively, in contrast to the larger somatic- ry lobes and smaller facial lobes in the brain of the whiting, suggestive of a more active predatory

Thus, differences in feeding habits are necessarily reflected in the nature of the food consumed, haddock browsing along on the bottom and ingesting echinoderms, annelids, molluscs, Crustacea sometimes sand eels), whilst the whiting chiefly pursues small fish and the more active Crustacea on bove the bottom. Earlier observations are clearly in general agreement with this, but the records whole show that (subject to this generalisation) the actual species consumed may vary considerably. s, whereas the whiting examined during 1949 were found to be principally feeding on *Gadus esmarkii* mmodytes, according to their size and the distribution of these food species, previous workers in tish waters make no mention of *Gadus esmarkii*. In their surveys of the food of whiting, Matthews

Smith and Scott based their results on small numbers of stomachs mainly from Scottish coastal wa where *Gadus esmarkii* is not always abundant. The principal fish mentioned were herring, sprats, wh and Ammodytes. In the southern North Sea, where *Gadus esmarkii* rarely occurs, whiting have found feeding on herring, whiting, Ammodytes and Branchiostoma (Hertling, 1938). Again, Par mentions taking from the deep water to the east of the Shetlands whiting that were feeding al exclusively on mackerel.

With regard to haddock, results similar to those shown here have been obtained by other wor although it seems likely that Ammodytes may sometimes be more important in the diet than has found from this survey. Ritchie (1937), for instance, has found that in July haddock from the M Firth were sometimes gorged with this species although not invariably so.

On the strength of the evidence presented here it may at least be said that the overlap in diet i very marked and is mainly restricted to crustaceans. There is in fact a fundamental difference bet the predatory whiting, snapping up fish species and the active members of the bottom fauna, and haddock, which may be pictured as browsing on sedentary as well as on the less active bottom organ and seeming only to indulge in a fish diet when an abundance of Ammodytes is encountered. evidence of any inter-specific predation has been observed between haddock and whiting, but it i unusual for large whiting to eat small whiting, particularly in the latter part of the year, from July onw after the O-group has reached a size when it is likely to have taken to the bottom. No records of had in the stomachs of whiting or haddock were obtained at any time, however, nor of whiting in the haddock. Direct competition, therefore, seems (on this evidence) to be slight.

SEASONAL WEIGHT VARIATIONS IN THE CONTEN OF WHITING STOMACHS

Before going on to discuss seasonal variation in the stomach content weights of whiting it is rel to enquire into the nature of the variations in weights within any one sample. In the major instances histograms of stomach content weights were found to be highly skewed (Figs. 5), most c stomachs containing relatively little food material.

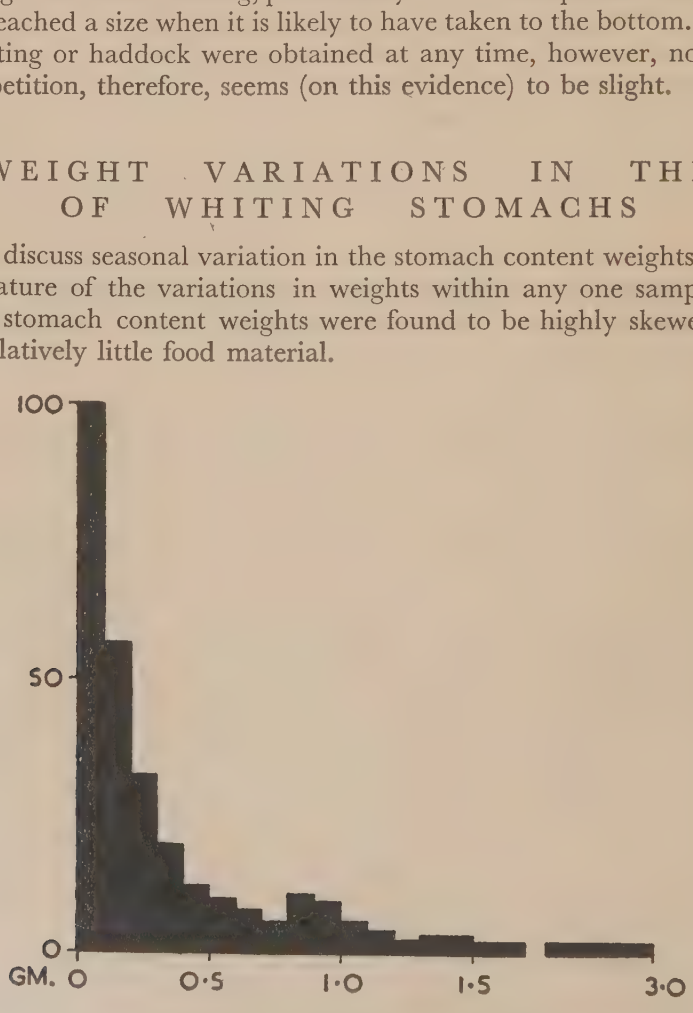


Fig. 5 Histogram of the stomach content weights, taken in March, from whiting of less than 21 cm. in length.

*Parrish—unpublished report of cruise on F.R.S. *Explorer*, October-November, 1947.

It is interesting to enquire what part disgorging might play in this phenomenon. It is true that this curs in whiting over 20 cms. in length, but a careful examination of the smaller whiting of the sizes own in Figs. 5-6a revealed no signs of disgorging such as particles of food in the teeth or gills. Further- ore the percentage of empty stomachs in these whiting was much less than that in the larger groups, is shown below:

Size Group	Empty	Not Empty	% Empty	
Under 21 cm.	151	1718	8.1	
21-25 cm.	187	708	20.9	
26-30 cm.	143	455	23.9	Weighted mean
31-35 cm.	93	328	22.1	21.8%
36-40 cm.	21	102	17.1	

There is no significance in the difference between the four size groups over 20 cms. in length (Chi- ared (3)=3.6), but a comparison of these with the under 21 centimetre group gave a value of Chi- ared equal to 122.6. The probability of so large a value arising by chance from similar statistical ulations is less than 0.001. It may, therefore, be concluded that there was a significantly greater portion of empty stomachs in the larger whiting, and it is possible that this was partly due to the gorging on capture.

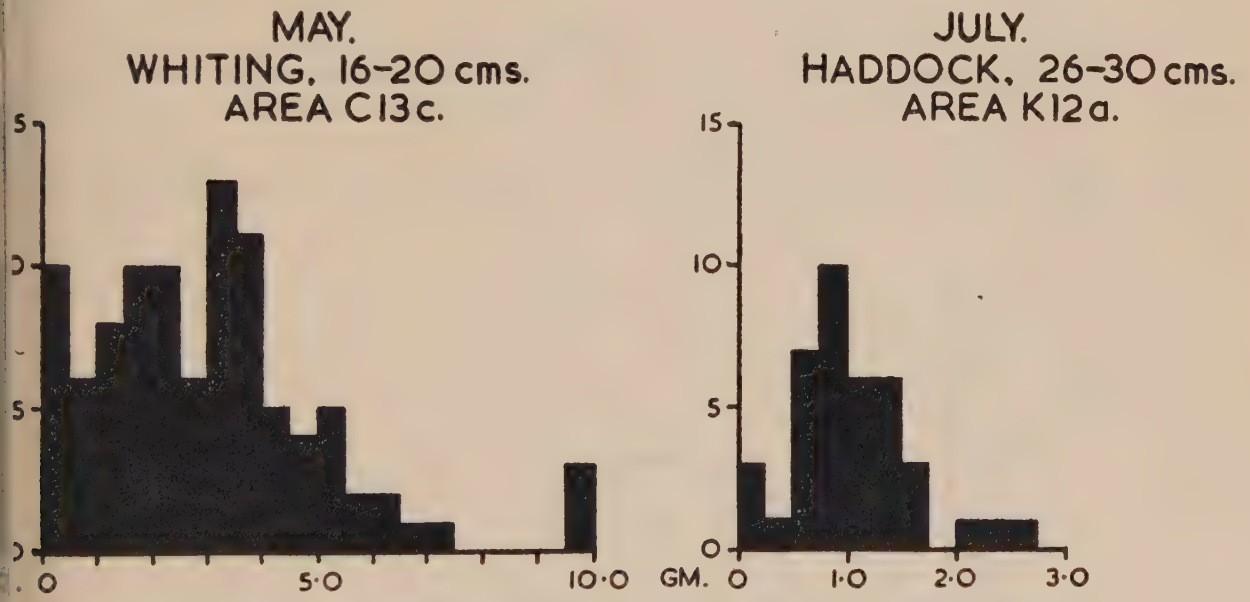


Fig. 6 Histograms of stomach content weights in whiting and haddock:—
(*a*) from whiting of 16-20 cm. in length in May (area C13c),
(*b*) from haddock of 26-30 cm. in length in July (area K12a).

In many cases, there were insufficient of the larger whiting taken per sample to enable efficient parison to be made between mean weights. This fact, coupled with an unknown bias due to some orging on capture, has prevented any further conclusions being drawn from these fish and the rest of section will be devoted to a description of the stomach content weights of whiting less than 21 cm. in th.

If the skewed distributions met with are not to be explained by disgorging in the smaller whiting any other hypothesis be advanced to account for them?

A possible explanation was suggested from certain observations on *Gadus esmarkii* found in the whi stomachs. This species was generally doubled on itself, and even when digestion was well advan in the exposed part, the epidermis within the fold of the body was practically untouched. In o words, the gastric juices had little power of penetration so that digestion was restricted to the surfac the prey.

It seems reasonable to suppose therefore that the tendency of the digestive juices is to decrease *radius* of such a food mass at a constant rate, rather than its *mass*. Consequently, the decrease in we of each fish would be more rapid during the early stages of digestion when the surface area was la than in the later stages when it was small. The bony centre of the organism would further exagge this tendency.

If, then, a fresh food organism were not ingested until the previous one had been completely diges the probability of finding a considerably digested food mass would be greater than that of finding a digested one. In other words, a distribution of stomach content weights could be expected to asymmetrical, with a predominance of small weights, and only a few really distended stomachs.

If, on the other hand, some whiting ingested fresh food organisms a considerable time before previous ones had been eliminated from their stomachs, the probability of finding an empty stomac a sample would be reduced. This is doubtless what occurred in a sample of small whiting taken in I (Fig. 6a) which had been gorging on Ammodytes.

Haddock samples showed similar histograms to these (Fig. 6b) as may be expected of a fish that f in a more or less continuous manner.

From these considerations, it is clear that the mean of a sample of stomach content weights n not necessarily bear any fixed relationship to the quantity of food actually ingested. In fact, su quantity should be defined in terms of weight eaten per unit time, and without a measure of the of digestion, a measure of this quantity cannot be obtained from the stomach content weights a

Also, owing to the skewed nature of the distributions, the arithmetic mean of a sample of stor content weights is subject to a rather high error variance and it is worthwhile enquiring whether a efficient index of such a sample may be found.

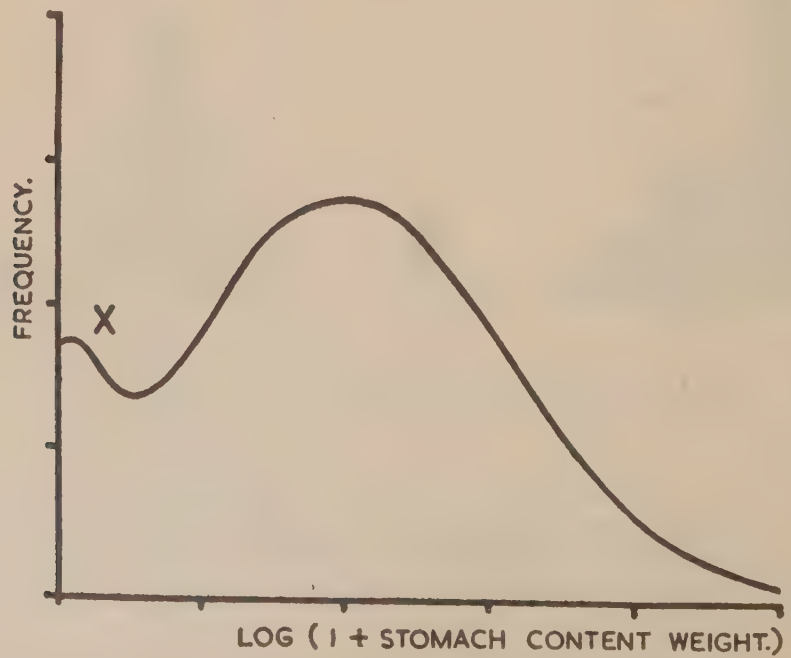


Fig. 7 Frequency distribution of logarithms of stomach content weights. The subsidiary peak X was due to inclusion of completely empty stomachs (see page 17).

A possible method was suggested when an analysis of a number of these distributions revealed a dency for the standard deviation of a stomach content weight to be proportional to its mean. The ependence of these two statistics is a necessary condition for the carrying out of statistical comparisons amples (which will be done later) and, in order to fulfil this condition, it is necessary to transform he logarithms of the stomach content weights.

In order to include completely empty stomachs, the logarithm of 1 plus each stomach content ght was first tried, but the resulting curve was not normal (see Fig. 7). A closer approximation to mality was finally obtained by ignoring the empty stomachs and taking straight logarithms.

The mean of such a transformed distribution is not readily influenced by exceptionally full stomachs its antilogarithm (or geometric mean) is therefore a more efficient estimate than the arithmetic an of the untransformed weights. Geometric means rather than arithmetic means were therefore ulated for each sample and are shown in Fig. 8 along with the percentages of empty stomachs.

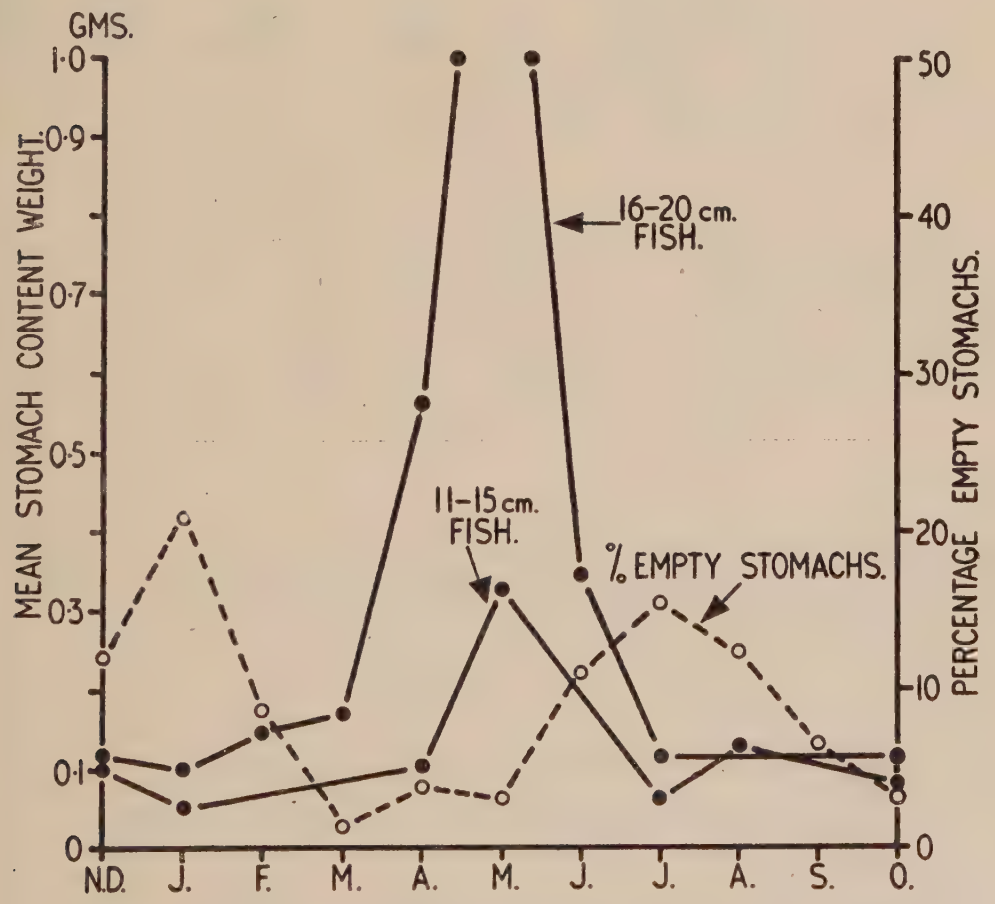


Fig. 8 Seasonal variations in the geometric means and in the proportion of empty stomachs found in whiting of less than 21 cm. in length.

monthly mean weight was based on samples from various times of the day so that any diurnal tions in food (page 18) would tend to be averaged out. The mean stomach content weights remained oximately constant at a level of 0.1 gms. during the autumn and winter months, with marked increases March, rising to 1.7 gms. for whiting of 16-20 cm. in length, and to 0.33 gms. for those of 11-15 during May, when the fish were feeding on Ammodytes. At the same time there was a decrease in ercentage of empty stomachs from 21% in January to 1-3% in March and May.

These two effects, which were also accompanied by a change in the distribution of stomach co weights from the type in Fig. 5 to that in Fig. 6a, are indicative of a real change in the intens feeding. It may be concluded then that there was a real and marked increase in the rate of feeding d March and April rising to a peak in May, when the whiting samples were gorging on Ammodytes. appears to have been a corresponding but reverse change after May.

DIURNAL FEEDING VARIATIONS

In order to determine whether feeding was more intense at one time of the day than at any ot series of samples was collected at different times of the day from the same area. This was done in A from sub-square H5c, and 155 whiting, measuring 21-25 cm. in length, were obtained.

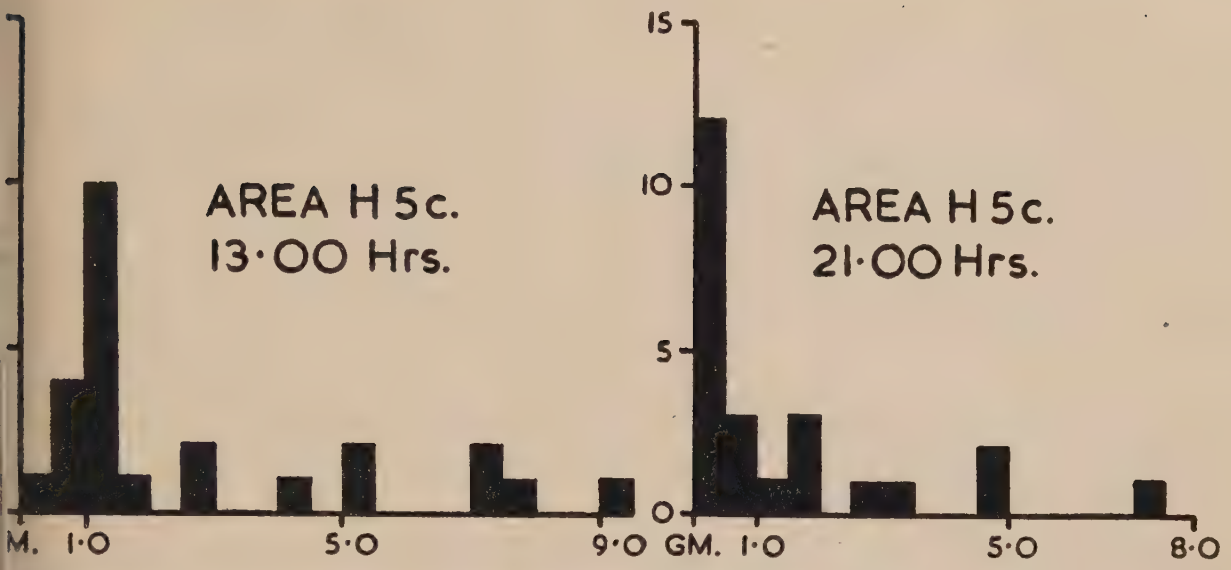
The geometric mean weights of the stomach contents were estimated for the sample taken at time of the day and these results are shown below:

Mean log. of stomach content weights	Geometrical mean	Time of capture (B.S.T.)
0.0733	1.18	0730 hours
0.1920	1.56	1000 „
0.2418	1.74	1300 „
—0.0137	0.73	1530 „
—0.0144	0.72	1830 „
—0.3429	0.45	2100 „

In order to determine whether these differences in the mean logarithms were likely to be d chance variations or not, an analysis of variance was carried out on the logarithms of the stomach co weights, the results of which are set out below:

Source of Variation	Degrees of freedom	Sum of Squares	Mean Sq.	F
Within Samples	149	63.84	0.428	
Between Samples	5	5.29	1.058	2.47
Total	154	69.13		

This value of F would arise only in about 4% of cases by pure chance if all six samples were fro same (statistical) population, and it may be concluded that on this occasion there was probably difference between the means of the different samples. This was supported by a comparison frequency distributions of stomach content weights, two of which are shown in Figs. 9a and 9b



9 Histograms of stomach content weights taken at different times of the day in area H5c at (*a*) 13.00 hours and (*b*) at 21.00 hours.

other four samples gave histograms intermediate in shape between these two and are therefore in ort of the conclusion that feeding was more intensive around midday than during early morning ate evening. The histogram in Fig. 9b is that of the sample taken at 2100 hours, which had the st mean weight, whereas that in Fig. 9a is of the sample taken at 1300 hours, with the highest mean ght. It should be emphasised that, although convincing in itself, this one example may not be taken onclusive evidence of diurnal feeding variations in general.

SUMMARY

The stomachs of some 4,300 whiting and 900 haddock were collected for stomach analysis by the arch ships of the Scottish Home Department during the period November 1948 to December 1949. fish were first sorted into 5 cm. groups and the percentage weights and occurrence of each phylum species found in the stomachs were recorded.

The principal food organisms in the diet of the northern North Sea whiting were fish and crustaceans, annelids and molluscs forming very secondary items of diet. Echinoderms were very rarely rded in any stomachs.

The principal fish consumed by small whiting (less than 21 cm. in length) was Ammodytes, whilst *s esmarkii* predominated in the larger size groups.

Crangon allmanni was the principal crustacean in the stomachs of whiting of all size groups. The ler fish of 25 cm. or less, in which the proportion of Crustacea reached its highest value, contained eater variety of species than did the larger fish, which contained principally Decapoda Natantia Reptantia as well as several species of amphipods. Annelids recorded comprised eleven species of nt polychætes and six sedentary species, while the molluscs included small cephalopods and portions stropod feet.

5. With increase in size of whiting there was an increase in the proportion of fish eaten, with a corr ponding decrease in the proportion of Crustacea, at all times of the year.

6. The whiting is an active predator, feeding principally on fish and more active crustaceans, chi Decapoda Natantia and amphipods, whereas the haddock is more exclusively a bottom feeder, perh exercising less selection, and feeding on echinoderms, annelids, molluscs and Crustacea. Fish sometir bulked largely, but only intermittently.

7. No haddock were recorded in the whiting stomachs and there was no evidence of serious competit for food occurring between these two species in the northern North Sea.

8. The frequency distributions of stomach content weights were generally very skewed, owing t relatively high proportion of empty or nearly empty stomach content weights. The inefficiency of arithmetic mean as an index of such a distribution is discussed, and reasons advanced for preferring geometric mean for this purpose.

9. Small whiting, under 21 cm. in length, sampled in May from areas B11 and C13, were found to feeding more intensely than at any other time. These fish were feeding almost exclusively on Ammody

10. Evidence of disgorging on capture was found in whiting more than 20 cm. in length and this reflected by the larger proportion of empty stomachs in these fish than in the smaller whiting which not disgorge.

11. In one instance at least there was evidence of a diurnal variation in the intensity of feeding whiting.

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TABLE I

Relative Occurrence and Percentage Weight (as weighted mean) of Different Food Groups in Whiting of <21 cm. in length.

Month	Relative Occurrence					Percentage Weight					Number
	F*	C	A	M	E	F	C	A	M	E	
1948 Nov.-Dec.	10	62	14	3	—	22	64	12	2	—	239
1949 January	28	51	—	—	—	51	49	—	—	—	18
February	34	45	27	2	—	60	14	21	5	—	164
March	37	50	23	4	1	73	17	8	2	+	374
April	16	75	—	9	—	29	62	—	9	—	62
May	92	21	6	—	—	96	3	1	+	—	247
June	42	25	—	—	—	94	6	—	—	—	40
July	15	83	12	1	—	27	52	18	3	—	289
August (8-10 cm.)	31	79	5	—	—	73	21	6	—	—	19
August (11-15 cm.)	87	13	13	—	—	78	1	21	—	—	15
September	10	81	5	4	—	18	73	3	6	—	283
October	9	86	5	2	—	20	70	5	6	—	128

TABLE II

Relative Occurrence and Percentage Weight (as weighted mean) of Different Food Groups in Whiting of 21-25 cm. in length

Month	Relative Occurrence					Percentage Weight					Number
	F*	C	A	M	E	F	C	A	M	E	
1948 Nov.-Dec. (21-30 cm.)	46	34	2	—	—	79	20	—	1	—	40
1949 January	8	63	6	—	—	16	73	11	—	—	46
March	67	50	—	—	—	88	12	—	—	—	18
April	37	29	—	11	7	75	4	—	20	1	27
May	92	20	24	4	—	96	1·3	1·4	1·3	—	25
July	22	74	16	2	+	54	30	9	6	1	215
August	43	77	1	8	—	64	35	+	1	—	150
September	20	85	7	—	—	68	30	—	2	—	87
October	9	90	6	1	2	58	38	2	2	+	89

*F Fish
C Crustacea
A Annelids
M Molluscs
E Echinoderms
+ Negligible

TABLE III

Relative Occurrence and Percentage Weight (as weighted mean) of Different Food Groups in Whiting of 26-30 cm. in length

Month	Relative Occurrence					Percentage Weight					Number
	F*	C	A	M	E	F	C	A	M	E	
1949 January	2	74	2	4	—	2	55	5	38	—	23
March	78	33	2	1	—	96	3	+	1	—	114
April	49	34	31	—	—	87	6	7	—	—	68
May	81	12	19	6	—	92	0·5	0·5	7	—	16
July	29	69	16	4	—	42	51	5	2	—	126
August	32	81	10	—	—	19	79	2	—	—	31
September	59	66	3	4	—	89	11	+	+	—	81
October	64	48	6	—	—	96	5	1	—	—	17

TABLE IV

Relative Occurrence and Percentage Weight (as weighted mean) of Different Food Groups in Whiting of 31-35 cm. in length

Month	Relative Occurrence				Percentage Weight				Number
	F*	C	A	M	F	C	A	M	
1948 Nov.-Dec.	57	59	—	—	80	20	—	—	63
1949 January (31-40 cm.)	25	87	—	—	62	38	—	—	6
March	84	40	14	2	99	1	+	+	94
April	67	38	3	3	94	2	+	4	37
August	34	92	6	3	29	69	1	1	35
September	74	38	—	5	94	5	—	1	64
October	73	27	—	—	99	1	—	—	11

*F Fish
C Crustacea
A Annelids
M Molluscs
E Echinoderms
+ Negligible

TABLE V

Relative Occurrence and Percentage Weight (as weighted mean) of Different Food Groups in Whiting of 36-40 cm. in length

Month	Relative Occurrence				Percentage Weight				Number
	F*	C	A	M	F	C	A	M	
1948 Nov.-Dec.	48	66	5	5	51	41	+	8	41
1949 March	91	13	4	—	98	2	+	—	24
April	82	29	12	—	98	1	1	—	17
September	80	47	—	7	21	30	—	49	15
October	80	—	—	20	88	—	—	12	5

TABLE VI

Relative Occurrence and Percentage Weight (as weighted mean) of Different Food Groups in Whiting of 41-45 cm. in length

Month	Relative Occurrence				Percentage Weight				Number
	F*	C	A	M	F	C	A	M	
1948 Nov.-Dec.	68	32	—	—	94	6	—	—	28
1949 January	100	50	—	—	99	1	—	—	2
March	100	—	—	—	100	—	—	—	7
April	100	50	—	—	100	+	—	—	4
September	100	100	—	—	89	11	—	—	1
October	100	50	—	—	100	+	—	—	2

*F Fish
C Crustacea
A Annelids
M Molluscs
+ Negligible

Occurrence of Recognisable Food Organisms in Whiting <21 cm. in length

	Nov. Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Sep.	Oct.
Ammodytes	1		38	30	5	90	39	2	1	
G. esmarkii									1	
G. merlangus								1	1	
All Gadoids								4	1	
Hippoglossoides platessoides					5					
Argentina									1	
Gobius minutus	1			1				1	1	3
Lepidorhombus whiffiagonis									1	
Crangon	25	5	11	9	22	3		21	9	12
Pandalus	1		1	2		2		1	4	2
Hippolyte	1									
Nika	8			5	35	1		4	2	15
Calocaris	1									1
Portunus			1					2	6	1
Eupagurus								2		1
Cirolana							1			
Idothea							1			1
Eurydice			1							
Mysidacea	6	30	2	7	30	4	7	25		7
Euphausiacea	5	5	1	5					3	
Amphipoda	9	35	26	24	10	12	1	34	12	6
Copepoda									15	30
Crustacea juv.										
Aphrodite									1	1
Other Polynoidae				9	2			3	3	4
Phyllodoce			8	2				2		
Goniada		3						+		
Nephthys						2		1		1
Nereis			2							
Arenicola		2								
Terebellidae			1					+		
Pectinaria								2		
Cephalopoda	1		1	1	9			1	1	2
Whelk's feet								1		
Abra			1							
Cultellus				+						
Gastropoda juv.									2	
Ophiura				+						

Percentage Weights of Different Food Organisms in Whiting <21 cm. in length

(Each percentage is expressed as a percentage of the recognisable food material of its own phylum, and not as a percentage of the total food mass.)

	Nov. Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Sep.	Oct.
Ammodytes	90		100	99	70	100	100	52	9	
G. esmarkii									44	
G. Merlangus								24	33	
All Gadoids								47	78	
Hippoglossoides platessoides					30					
Argentina									5	
Gobius minutus	2			1				1	5	100
Lepidorhombus whiffiagonis									3	
Crangon	47	4	70	33	38	20		27	26	30
Pandalus	3		0·5	8		22		1	14	
Hippolyte	5									
Nika	13			15	50	9		3	3	13
Calocaris	7									9
Portunus			25					10	6	4
Eupagurus								10		14
Cirolana							48			
Idothea							1			+
Eurydice			0·5				48			
Mysidacea	3	17	0·5	5	1	+	+	15		6
Euphausiacea	7	4	0·5	24					26	
Amphipoda	7	75	?	15	1	47	1	33	25	4
Copepoda									+	20
Crustacea juv.										
Aphrodite									2	15
Other Polynoidae				55	80			17	45	85
Phyllodoce			9					9		
Goniada			8					+		
Nephthys				8		75		65	53	
Nereis				5						
Arenicola			75	21						
Terebellidae				11				0·5		
Pectinaria								8		
Cephalopoda	100		95	98	100			57	63	100
Whelk's feet								43		
Abra			5							
Cultellus				2						
Gastropoda juv.									37	
Ophiura				100						

TABLE IX

Relative Occurrence of Recognisable Food Organisms in Whiting 21-25 cm. in length

	*Nov. Dec.	Jan.	Mar.	April	May	July	Aug.	Sept.	Oct.
Ammodytes	—	2	22		92	1	9		
G. esmarkii	38		28	18	4	1		2	4
G. merlangus	2					1		2	2
All Gadoids	43	2	28	18	4	10		4	7
Hippoglossoides platessoides						1		1	
Solea							8		
Gobius minutus						1	1		
Clupea harengus							16	6	
Herring scales				7					
Amphioxus						1			
Crangon	26	24	22	4	8	19	30	22	29
Pandalus		5			8				1
Nika			6			3	2	12	22
Calocaris									1
Portunus	2	2				3	50	2	1
Eupagurus		13				4	5	1	1
Cirolana	2								
Mysidacea		22				23		2	
Euphausiacea		33							
Amphipoda		31	11	11		26		36	5
Copepoda									18
Aphrodite	2	5				1		5	4
Other Polynoidae						2			
Phyllodoce						1			
Goniada						2	1		
Nephthys					8	1			
Nereis						1			1
Amphitrite						2			
Pectinaria							1		
Hyalinoecia									2
Loligo				4	1	1	2		
Cephalopoda						1			
Whelk's feet						1			
Abra									
Amphiura				7					2
Holothuria						1			

TABLE X

Percentage Weights of Different Food Organisms in Whiting 21-25 cm. in length. (See Table VIII).

	*Nov. Dec.	Jan.	Mar.	Apr.	May	July	Aug.	Sept.	Oct.
Ammodytes	—	47	20		92	14	17		
G. esmarkii	86		80	97	8	1		2	55
G. merlangus	4					10		66	31
All Gadoids	100	52	80	100	8	84		68	100
Hippoglossoides platessoides						1		1	
Solea							5		
Gobius minutus						1	2		
Clupea harengus							77	30	
Herring scales				+					
Amphioxus						+			
Crangon	90	19	68	25	35	16	6	38	61
Pandalus		15			65				2
Nika			31			1	1	7	29
Calocaris									4
Portunus	2	17				10	80	3	1
Eupagurus		11				36	40	8	2
Cirolana	2								
Mysidacea		3				14		1	
Euphausiacea		32							
Amphipoda		3	+	75		14		39	1
Copepoda									?
Aphrodite	100	100				13		100	43
Other Polynoidae						19			
Phyllodoce						1			
Goniada						66	87		
Nephthys					100	2			
Nereis						1			57
Amphitrite						2			
Pectinaria							13		
Hyalinoecia									100
Loligo				100	100	40	100		
Cephalopoda						59			
Whelk's feet						1			
Abra									
Amphiura				100		100			100
Holothuria									

TABLE XI

Relative Occurrence of Recognisable Food Organisms in Whiting 26-30 cm. in length.

	Jan.	Mar.	April	May	July	Aug.	Sept.	Oct.
G. esmarkii	?	44	23	31	1	7	15	19
G. merlangus					2		5	25
All Gadoids		51	28	31	6	7	26	50
Ammodytes				75			3	
Hippoglossoides platessoides		1	3					
Gobius minutus						3		
Clupea harengus ..					5			6
Herring spawn ..							5	
Herring scales			1					
Argentina		3						
Callionymus							3	
Branchiostoma					3			
Crangon	16	17	10	6	9		26	25
Pandalus			1		2		1	
Nika		8	3		2		1	12
Calocaris							1	
Eupagurus	4	1	3		26		5	
Portunus					6			
Galathea					2			
Cirolana							3	
Hyperia+Themisto ..						71	3	
Other Amphipoda ..	24		10		28			6
Mysidacea	4		3		15			
Euphausiacea	28							
Polynoid remains ..			4					6
Phyllodoce			6		8			
Nephthys					5		1	
Whelk's feet	4		2	6	2			
Cephalopod remains ..			1				4	

TABLE XII

Percentage Weights of Different Food Organisms in Whiting 26-30 cm. in length. (See Table VIII).

	Jan.	Mar.	Apr.	May	July	Aug.	Sept.	Oct.
G. esmarkii	?	54	91	77	16	55	64	54
G. merlangus					19		23	36
All Gadoids		97	95	77	73	55	93	92
Ammodytes				23			1	
Hippoglossoides platessoides		2	5					
Gobius minutus						2		
Clupea harengus					27			8
Herring spawn							5	
Herring scales			+					
Argentina		1						
Callionymus							9	
Branchiostoma					+			
Crangon	36	72	34	100	2		52	74
Pandalus			23		1		5	
Nika		24	22		1		1	25
Calocaris							25	
Eupagurus	3	4	16		82			
Portunus					8			
Galathea					1			
Cirolana							6	
Hyperia+Themisto ..						97	11	
Other Amphipoda ..	1		3		3			1
Mysidacea	+		2		1			
Euphausiacea	60							
Polynoid remains ..			76					100
Phyllodoce			24		24			
Nephthys					76		100	
Whelk's feet	100		40	100	100			
Cephalopod remains ..			60				100	

TABLE XIII

Relative Occurrence of Recognisable Food Organisms in Whiting 31-35 cm. in length.

	Nov. Dec.	Jan.*	Mar.	April	Aug.	Sept.	Oct.
G. esmarkii	8		43	35	6	3	27
G. merlangus	6					8	36
All Gadoids	18		50	43	11	50	64
Hippoglossoides platessoides			6	3		1	9
Ammodytes						3	
Argentina	3						
Crangon	43	84	4	19		19	9
Pandalus	9		1	3			
Nika	3		1				
Eupagurus				3		2	
Cirolana	2		1				18
Mysidacea		16		5			
Euphausiacea		33					
Hyperia and Themisto					83		
Other Amphipoda	13			3		12	
Nereis			1				
Cephalopod remains				3		5	
Amphiura						1	

TABLE XIV

Percentage Weights of Different Food Organisms in Whiting 31-35 cm. in length. (See Table VIII)

	Nov. Dec.	Jan.*	Mar.	April	Aug.	Sept.	Oct.
G. esmarkii	48		70	76	26	70	48
G. merlangus	37					12	38
All Gadoids	90		93	98	64	97	90
Hippoglossoides platessoides			7	2		1	10
Ammodytes						2	
Argentina	8						
Crangon	83	98	28	32		41	17
Pandalus	12		23	64			
Nika	3		36				
Eupagurus				2		8	
Cirolana	1		13				83
Mysidacea		+		1			
Euphausiacea		2					
Hyperia and Themisto					99		
Other Amphipoda	1			1		50	
Nereis			106				
Cephalopod remains				100		100	
Amphiura						100	

*Whiting of 31-40 cm. in length

TABLE XV

Relative Occurrence of Recognisable Food Organisms in Whiting 36-45 cm. in length.

	36-40 cm.					41-45 cm.					
	Nov. Dec.	Mar.	Apr.	Sep.	Oct.	Nov. Dec.	Jan.	Mar.	Apr.	Sep.	Oct.
G. esmarkii ..	8	50	59	20	20	28		86	75	100	100
G. merlangus ..	5			20	60	25	50				
All Gadoids ..	15	58	64	60	80	60	50	100	75	100	100
Hippoglossoides platessoides ..					20				25		
Clupea harengus ..				7			100				
Herring scales ..											
Ammodytes ..			6								
Gobius minutus ..	5										
Argentina ..	5	4									
Crangon ..	55		18	7		36			40		50
Pandalus ..	5		12			7				100	
Nika	5			7							
Eupagurus ..				7							
Portunus ..	2										
Munida ..		4									
Cirolana ..	5			7		11					
Mysidacea ..											
Euphausiacea ..											
Hyperia+ Themisto ..				20							
Other Amphipoda	10					7					
Nephthys ..		4									
Aphrodite ..	2										
Loligo				7	20						
Cephalopod remains ..	5			7	20						

TABLE XVI

Percentage Weights of Different Food Organisms in Whiting 36-45 cm. in length. (See Table VIII).

	36-40 cm.					41-45 cm.					
	Nov. Dec.	Mar.	Apr.	Sep.	Oct.	Nov. Dec.	Jan.	Mar.	Apr.	Sep.	Oct.
G. esmarkii ..	51	96	90	24	20	44		95	84	100	100
G. merlangus ..	40			56	69	43	25				
All Gadoids ..	96	100	99	99	89	94	25	100	84	100	100
Hippoglossoides platessoides ..					11				16		
Clupea harengus ..				1			75				
Herring scales ..			+								
Ammodytes ..			1								
Gobius minutus ..	1										
Argentina ..	3	+									
Crangon ..	90		70	1		69			100		100
Pandalus ..	1		30			9				100	
Nika	2			1							
Eupagurus ..				1							
Portunus ..	5										
Munida ..		100									
Cirolana ..	2			1		19					
Mysidacea ..											
Euphausiacea ..											
Hyperia+ Themisto				95							
Other Amphipoda	1					3					
Nephthys ..		+									
Aphrodite ..	80										
Loligo				100	100						
Cephalopod remains ..	100			100	100						

TABLE XVII

Species found in Whiting and Haddock Stomachs

	Size Groups											
	1		2		3		4		5		6	
Gadus esmarkii, Nilsson	H	W	—	W	H	W	H	W	H	W	H	W
„ *merlangus*, L.	—	W	—	W	—	W	—	W	—	W	—	W
„ *minutus*, L.	—	—	H	W	—	W	—	—	H	—	—	—
Ammodytes tobianus, L.	H	W	H	W	H	W	H	W	H	W	H	W
Gobius minutus, Gmelin	—	—	H	—	—	—	—	—	—	—	—	—
Crystallogobius Nilssoni, (Duben and Koren)	—	W	—	—	—	—	—	—	—	—	—	—
Hippoglossoides platessoides (Fabricius)	—	W	—	W	—	W	—	W	—	W	—	W
Lepidorhombus whiff-iagonis (Walbaum)	—	—	—	—	—	—	—	—	—	—	—	—
Solea spp., Quensel	—	—	—	W	—	—	—	—	—	—	—	—
Argentina sphyraena, L.	—	W	—	—	—	W	—	W	—	W	—	—
Clupea harengus, L.	—	—	—	W	—	W	H	W	H	—	—	W
Herring spawn	H	—	H	—	H	—	—	—	—	—	H	—
Onos tricirratus (Bloch)	—	—	—	—	—	W	—	—	—	—	—	—
Fierasfer sp. Cuvier	—	—	—	—	—	—	—	W	—	—	—	—
Sebastes juv.	—	—	—	—	—	—	H	—	H	—	—	—
Trigla gurnardus, L.	—	—	—	—	—	—	H	—	—	—	—	—
Branchiostoma lanceolata (Costa)	—	—	—	—	—	W	—	—	—	—	—	—
Crangon allmanni, Kinahan	H	W	H	W	H	W	H	W	H	W	H	W
„ *vulgaris*, L.	—	W	—	W	—	—	—	—	—	—	—	—
Pandalus montagui, Leach	H	W	H	W	H	W	H	W	—	W	—	W
Nika edulis, Bell	H	W	H	W	H	W	H	W	H	W	H	W
Hippolyte securifrons, Norman	—	W	—	W	—	W	H	W	—	—	H	
Galathea spp., Fabr.	H	—	H	—	H	—	H	W	H	—	H	
Munida bamffica (Pennant)	—	—	H	—	—	—	—	—	—	W	—	
Carcinus moenas, Leach	—	—	H	—	—	—	—	—	—	—	—	
Hyas coarctatus, Leach	H	—	—	—	H	—	H	—	H	—	H	
Calocaris macandreae, Mihi	—	W	—	W	—	W	—	W	—	—	—	
Eupagurus bernhardus, Bell	H	W	H	W	H	W	H	W	H	W	H	
„ *prideauxii*, Bell	—	—	—	—	—	W	—	W	—	—	—	
Portunus spp., Leach	H	W	H	W	H	W	H	W	H	W	H	
Atelecyclus septemdentatus, Leach	—	—	—	—	—	—	H	—	—	—	H	
Cirolana borealis, Lilljeborg	—	W	—	—	H	W	H	W	H	W	—	
Rocinela danmoniensis, Leach	H	—	—	—	H	—	—	—	—	—	—	
Eurydice pulchra, Leach	—	W	—	W	—	—	—	—	—	—	—	
Idothea baltica (Pallas)	—	W	—	—	—	—	—	—	—	—	—	
„ *emarginata* (Fabr.)	—	W	—	—	—	—	—	—	—	—	—	
„ *viridis* (Slabber)	—	W	—	—	—	—	—	—	—	—	—	
Astacilla longicornis (Sowb)	—	—	—	W	—	—	H	—	—	—	H	
Tiron acanthurus, Lilljeborg	—	W	—	—	—	—	—	—	—	—	—	
Bathyporeia norvegica, n.s.	—	W	—	W	—	—	—	—	—	—	—	
„ *pelagica*, Sp. Bate	—	W	—	W	H	—	—	W	H	—	—	
Podocerus falcatus (Mont.)	—	W	—	—	—	—	—	—	—	—	—	
Harpinia neglecta, G. O. Sars	—	W	—	W	—	W	—	W	—	—	—	
Themisto gracilipes, Norman	—	W	—	W	—	—	—	—	—	—	—	
Hyperia galba (Mont.)	—	W	—	W	—	—	—	—	—	—	—	
Hippomedon denticulatus (Sp. Bate)	H	W	H	W	H	W	H	W	H	W	H	
Tryphosites longipes, Bate and Westw.	—	W	—	W	—	W	—	W	—	W	—	
Ampelisca laevigata, Lilljeborg	H	W	H	W	H	W	H	W	H	W	H	
„ *macrocephala*, Lilljeborg	H	W	H	W	H	W	H	W	H	W	H	
„ *assimilis*, Boeck	H	W	H	W	H	W	H	—	H	—	H	

1. <21
2. 21-25
3. 26-30
4. 31-35
5. 36-40
6. >40 cm.

W Present in Whiting
H Present in Haddock
— Absent from either species.

TABLE XVII—(*Continued*)

Species found in Whiting and Haddock Stomachs

	Size Groups											
	1		2		3		4		5		6	
Nugas (Phipps)	—	—	—	—	H	—	H	—	—	—	—	—
norvegica, Boeck	—	—	—	—	H	—	—	—	—	—	—	—
hoe rubricata, Leach	—	—	H	—	—	—	—	—	—	—	—	—
planipes, Norman	—	—	H	—	H	—	—	—	—	—	—	—
edata (Muller)	H	W	H	—	H	—	—	—	H	—	—	—
anes couchii (Bell)	H	W	—	W	H	—	—	—	H	—	—	—
ctiphanes norvegica (M. Sars)	—	—	—	—	—	—	—	—	—	—	—	—
ysis ornata (G. O. Sars)	H	W	—	W	H	W	—	W	—	—	—	—
accus spinifer (Goes)	—	W	—	W	—	W	—	W	—	—	—	—
is gracilis (G. O. Sars)	—	W	—	—	—	—	—	—	—	—	—	—
ysis formosa, S. J. Smith	—	W	—	—	—	—	—	—	—	—	—	—
os sp., G. O. Sars	—	W	—	—	—	—	—	—	—	—	—	—
is sp., Say	—	W	—	—	—	—	H	—	—	—	—	—
mprops sp., G. O. Sars	—	W	—	—	H	—	—	—	—	—	—	—
la emarginata (Kroyer)	—	—	H	—	H	—	H	—	—	—	—	—
trispinosa (Goodsir)	—	—	H	—	—	—	—	—	—	—	—	—
rapax, M. Edwards	—	W	—	—	—	W	—	—	—	—	—	—
bipes (O. Fabricius)	—	W	—	—	—	—	—	—	H	—	—	—
a spp., Dana	—	W	—	W	—	W	—	—	—	—	—	—
s armatus, Boeck	—	W	—	—	—	—	—	—	—	—	—	—
ages typicus, Kroyer	—	W	—	—	—	—	—	—	—	—	—	—
longicornis (Muller)	—	W	—	—	—	—	—	—	—	—	—	—
finmarchicus (Gunner)	H	W	—	—	—	—	—	—	—	—	—	—
an larvae	—	W	—	W	—	—	—	—	—	—	—	—
te aculeata (L)	H	W	H	—	H	—	H	—	—	W	—	W
hoe spp., Kinberg	—	W	—	W	—	W	—	W	—	—	H	—
ntified Polynoids	H	W	H	W	H	W	H	W	H	—	H	—
maculata, Oersted	H	W	H	W	H	W	H	—	H	—	H	—
norvegica, Oersted	H	W	H	—	H	—	H	—	H	—	H	—
oce spp., Savigny	H	W	—	W	H	W	H	—	H	—	H	—
harassii, Audouin et M-Edwards	—	—	—	—	H	—	H	W	H	—	H	—
spp., Savigny	H	W	H	—	H	—	H	—	H	—	H	—
is sp., Cuvier	H	W	H	W	H	W	H	W	H	W	H	—
spp., Cuvier	—	W	H	W	H	W	H	W	H	—	—	—
ordmanni, Malmgren	H	—	—	—	H	—	H	—	—	—	—	—
a marina (L)	H	W	—	—	—	—	H	—	—	—	—	—
s sp., Leuckart	—	W	—	—	—	—	—	—	—	—	—	—
ia auricoma (Muller)	H	W	H	W	H	—	H	—	H	—	H	—
sp., Savigny	—	W	—	—	—	—	—	—	—	—	—	—
ite sp., O. F. Muller	—	—	H	W	H	—	—	—	—	—	—	—
ecia tubicola (O. F. Muller)	—	W	—	W	H	W	H	W	—	—	H	—
peripatus, Claparède	H	W	—	—	—	—	—	—	—	—	—	—
des plumosa (O. F. Muller)	H	—	—	—	H	—	H	—	H	—	H	—
fusiformis, Delle Chiaje	H	—	H	—	H	—	H	—	H	—	H	—
eis Gunneri (Sars)	—	—	H	—	—	—	—	—	—	—	—	—
sp., Savigny	—	—	H	—	—	—	—	—	—	—	—	—
spp., Malmgren	—	—	—	—	—	—	H	—	—	—	H	—
dae, Malmgren	—	—	—	—	H	—	—	—	—	—	—	—
lidae, Grube	—	—	—	—	H	—	—	—	—	—	H	—
Orbesii, Steen	—	W	H	W	H	W	H	W	—	W	—	W
atlantica, D'orb	H	W	—	W	H	W	—	W	—	—	—	—

1. <21
2. 21-25
3. 26-30
4. 31-35
5. 36-40
6. >40 cm.

W Present in Whiting
H Present in Haddock
— Absent from either species

TABLE XVII (*continued*)

Species found in Whiting and Haddock Stomachs

	Size Groups											
	1		2		3		4		5		6	
Loligo media, L.	—	—	—	W	—	—	—	—	—	—	—	
Whelk's foot	—	W	—	W	H	W	H	—	—	—	H	
Turritella (shell)	—	W	—	—	—	—	—	—	—	—	—	
Cylichna cylindracea (Pennant)	H	W	H	—	H	—	H	—	H	—	H	
Natica (shell),	—	—	—	—	H	W	H	—	H	—	H	
Cultellus pellucidus (Pennant)	—	W	H	—	H	—	—	—	—	—	—	
Ovula acuminata, Brugiere	—	—	H	—	—	—	—	—	—	—	—	
Philine sp., Ascanius	H	—	H	—	H	—	H	—	H	—	H	
Lima subauriculata, (Montagu)	H	—	—	—	H	—	H	—	—	—	—	
Lima loscombi, Sowerby	—	—	—	—	—	—	—	—	—	—	H	
Gibbula sp., Leach	—	—	—	—	—	—	H	—	—	—	H	
Dentalium, L.	—	—	—	—	H	—	H	—	H	—	—	
Emarginula crassa, Sowerby	—	—	—	—	H	—	—	—	—	—	—	
Murex, spp,, L.	—	—	—	—	H	—	H	—	—	—	—	
Trochus zizyphinum (Jeffreys)	—	—	—	—	—	—	—	—	—	—	H	
Chiton sp., L.	H	—	—	—	H	—	H	—	—	—	H	
Cardium spp., L.	—	—	H	—	H	—	—	—	H	—	H	
Solen sp., L.	—	—	—	—	—	—	—	—	—	—	H	
Spisula subtruncata, Da Costa	H	—	H	—	H	—	H	—	H	—	H	
Eulima polita, L.	—	—	H	W	H	—	H	—	—	—	—	
Anomia spp., L.	—	—	—	—	—	—	H	—	—	—	H	
Pecten similis, Laskey	H	—	—	—	—	—	H	—	—	—	—	
Chlamys sp., Bolten	—	—	—	—	—	—	—	—	—	—	H	
Psammobia sp., Lamarck	H	—	—	—	—	—	—	—	—	—	—	
Tellina sp., L.	—	—	—	—	H	—	H	—	—	—	H	
Abra prismatica, Mont.	H	W	H	W	H	—	H	—	H	—	—	
Abra alba, Wood	H	—	—	—	—	—	—	—	—	—	—	
Veliger larvae	—	W	—	—	—	—	—	—	—	—	—	
Echinocyamus pusillus (O. F. Müller)	H	—	H	—	H	—	H	—	H	—	H	
Ophiura affinis, Lütken	H	—	H	W	H	—	H	—	H	—	H	
Ophiura albida, Forbes	H	—	H	—	H	—	H	—	H	—	H	
Amphiura filiformis (O. F. Müller)	H	W	H	W	H	—	H	—	H	—	H	
Amphiura chiajei, Forbes	H	—	H	—	H	—	H	—	H	—	H	
Ophiopholis aculeata (L)	—	—	—	—	H	—	H	—	—	—	H	
Ophiothrix fragilis (Abildgaard)	—	—	—	—	—	—	H	—	—	—	H	
Ophiura texturata, Lamarck	—	—	—	—	H	—	—	—	—	—	—	
Solaster papposus (L)	—	—	—	—	—	—	H	—	—	—	—	
Stronglyocentrotus sp., Brandt	—	—	—	—	H	—	H	—	H	—	H	
Echinocardium sp., Gray	—	—	—	—	H	—	—	—	—	—	—	
Echinocucumis hispida (Barrett)	—	—	—	—	H	—	H	—	—	—	H	
Holothuria juv., L.	—	—	—	W	—	—	—	—	—	—	—	
Pleurobrachia juv., Fleming	—	—	—	W	—	—	—	—	—	—	—	
Thuiaria thuia, L.	—	—	—	—	—	—	—	—	—	—	H	
Lineus sp., Sowerby	—	—	—	—	—	—	—	—	—	—	H	
Priapulus sp., Lamarck	H	—	—	—	H	—	—	—	—	—	—	
Anemone	—	—	—	—	—	—	—	—	—	—	H	
Ascidia sp., L.	—	—	—	—	—	—	H	—	—	—	—	
Fish offal	—	W	—	—	H	—	H	—	—	W	—	

1. <21
2. 21-25
3. 26-30
4. 31-35
5. 36-40
6. >40 cm.

W Present in Whiting
H Present in Haddock
— Absent from either species

TABLE XVIII

Relative Occurrence of Different Food Groups in Haddock Stomachs from the North Sea.

Size of Haddock (cm.) Month:	<21 cm.					21-25					26-30					31-35					36-40					41-45					>45					
	F	C	A	M	E	F	C	A	M	E	F	C	A	M	E	F	C	A	M	E	F	C	A	M	E	F	C	A	M	E	F	C	A	M	E	Number
Nov. Dec.	·	·	·	·	·	·	68	75	59	88	·	·	·	·	·	·	100	100	63	100	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	47
Mar.	·	·	30	80	40	·	64	·	7	86	·	55	27	38	78	12	80	48	44	88	15	77	77	54	92	·	·	·	·	·	·	·	·	·	·	109
April	·	30	52	22	74	·	70	85	90	100	3	46	77	67	74	7	57	74	74	64	·	25	75	67	75	18	29	70	29	70	·	·	·	·	·	167
May	39	46	22	6	92	30	38	38	19	89	6	47	41	75	82	4	71	50	97	61	·	·	·	·	·	·	33	100	100	100	·	83	50	67	100	140
July	·	·	·	·	·	2	66	70	39	20	1	64	92	59	36	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	180
Sept.	9	46	12	17	40	37	37	37	13	31	33	47	47	53	60	19	72	50	33	90	29	29	10	19	29	50	35	20	60	40	88	22	22	66	33	239
Oct.	·	44	·	·	55	·	45	60	50	45	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	29

Percentage Volumes of Different Food Groups in Haddock Stomachs from the North Sea.

Nov. Dec.	·	·	·	·	·	·	5	75	10	10	·	·	·	·	·	·	2	59	22	17	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	47
Mar.	·	·	25	50	25	·	61	·	6	33	·	59	7	16	18	10	41	13	10	25	36	34	11	9	9	·	·	·	·	·	·	·	·	·	·	109
April	·	2	41		57	·	·	·	·	·	+	21	62		17	13	5	54		28	·	+	59		41	27	7	45		21	·	·	·	·	·	167
May	47	1	66	3	43	49	3	9	2	37	23	10	17	23	37	40	5	33	5	17	·	·	·	·	·	·	+	9	69	22	·	9	3	3	85	140
July	·	·	·	·	·	3	16	60	7	14	+	15	80		5	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	180
Sept.	49	21	10	8	12	75	5	7	1	12	38	5	17	9	31	30	8	6	4	52	75	1	1	+	23	78	5	5	8	4	86	+	7	7	+	239
Oct.	·	44	·	·	56	·	21		79		·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	29

F Fish C Crustacea A Annelids M Molluscs E Echinoderms

TABLE XIX

Ratios of quantities of different Food Groups. Percentage Weight Whiting/Percentage Volume Haddock.

Size of Haddock (cm.) Month:	<21 cm.					21-25					26-30					31-35					36-40				
	F	C	A	M	E	F	C	A	M	E	F	C	A	M	E	F	C	A	M	E	F	C	A	M	E
March (N. Sea)	∞	∞	·6	·27	·05	·	·	·	·	·	∞	·25	·06	0	0	9·1	·05	·18	·63	0	·	·	·	·	·
April (N. Sea)	·	·	·	·	·	·	·	·	·	·	∞	30·0	·	·08	0	7·1	+	0		0	∞	10·0	0		0
May (Faroe)	∞	1·17	0	0	0	·	·	·	·	·	2·9	+	0	0	0	·	·	·	·	·	·	·	·	·	·
(N. Sea)	2·2	·15	·02	0	0	2·1	·28	·09	·17	·01	2·2	0	·07	·13	0	8·4		1·07		0	·	·	·	·	·
July (Faroe)	30·0	0	0	0	0	∞	0	0	0	0	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
(N. Sea)	·	·	·	·	·	73·0	2·7	·46	0	·3	400	2·5	·3	·16	0	·	·	·	·	·	·	·	·	·	·
Sept. (N. Sea)	20·0	7·5	·01	·06	0	1·1	0	·	·	0	7·98	1·2	0	0	0	10·0	·3	0	0	0	1·8	0	0	0	0
Oct. (N. Sea)	∞	1·5	·	∞	0	∞	0	0	0	0	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·

F Fish C Crustacea A Annelids M Molluscs E Echinoderms

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